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J.K.H.

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APPARATUS AND METHOD FOR FLUID CLEANING

FIELD OF THE INVENTION

The present invention relates to purification of fluids and in particular to the use of a centrifuge to purify oils of different types.

BACKGROUND ART

Centrifuges for the separation of solids from liquids are of two general types: (1) sedimentation centrifuges, which require a difference between the densities of the two or more phases; and (2) centrifugal filters, in which the solid phase is supported and retained on a permeable membrane through which the liquid phase is free to pass.

Liquid-liquid centrifugal separators may be considered as an extension of the first type. The particles of a disperse liquid phase exhibit the same characteristics as particles of dispersed solids.

The use of centrifuges covers a broad range of applications, from the separation of gases of different molecular weights to the dewatering of coal.

Sedimentation centrifuges remove or concentrate particles of solid in a liquid by causing the particles to migrate through the fluid radially outward toward or away from the axis of rotation, depending upon the density difference between particles and liquid. If there is no difference in the density of the phases, the centrifuge cannot achieve separation. The discharge of the liquid may be intermittent, as in the case of the bottle or laboratory centrifuge.

In commercial centrifuges, the liquid-phase discharge is usually continuous. The heavy-solid phase is deposited against the bowl wall for intermittent removal, either manually or by the action of a cutter knife; for continuous removal, by a differential screw conveyor; or for intermittent or continuous discharge with a portion of the continuous liquid phase through appropriate openings in the periphery of the bowl.

The time required for solids removal may be as much as an hour for completely manual operation or as little as a few seconds for fully automated intermittent operation. When the separated solids have less density than the continuous phase, they can be removed from the surface of the liquid with a skimming tube.

The tubular bowl centrifuge is widely employed for purifying used lubricating and other industrial oils and in the food, biochemical and pharmaceutical industries.

The bowl is suspended from an upper bearing and drive assembly through a flexible-drive spindle. It hangs freely with only a loose guide in a controlled damping assembly at the bottom. Thus it can find its natural axis of rotation if it becomes slightly unbalanced because of its process load.

Feed enters the bottom of the bowl through a stationary feed nozzle under pressure. The pressure and nozzle size are selected to give a clean jet upward into the bowl at the desired flow rate. The incoming liquid is accelerated to rotor speed, moves upward through the bowl as an annulus, and discharges at the top.

Solids travel upward with the liquid and, at the same time, receive a radial velocity based on their size and weight in the centrifugal-force field. If the trajectory of a given particle intersects the bowl wall, the particle is removed from the fluid; if it does not, the particle appears in the effluent. Successful process performance depends on the correct balance of many factors.

The depth of the liquid layer is controlled by the radial position of the overflow port at the top of the bowl. To accelerate and maintain the liquid at the rotational speed of the bowl, an internal vane set, frequently of the Y or trefoil form, is provided. It also serves to damp surge waves and minimise out-of-balance during deceleration.

The centrifuged liquid leaves the top of the bowl at the peripheral velocity of the overflow port. Not only is it subject to high shearing forces at this point, but it also strikes the casing or collection cover with considerable force and breaks into small droplets. If its surface tension is low, foaming may result. If this is deleterious to the product, as in the case of fruit juices, it may be desirable to remove the liquid from the top of the bowl by a skimmer or "centripetal" pump. In another configuration, the "full-bowl" principle, the feed and discharge openings are equipped with radial or face seals and no air- liquid interface is present in either the bowl or the discharge from it.

By providing two liquid outlets at different radii and different elevations

at the top of the bowl, it is possible to separate continuously two immiscible liquids of different density while solid particles are collected from either or both phases. The positioning of the interface inside the bowl between the separated liquids is usually controlled for optimum performance by adjustment of the heavy-phase outlet with an interchangeable washer or "ring dam" of selected inside diameter. Tubular-bowl centrifuges are available with a variety of casings and covers for the containment of noxious vapours and of volatile or flammable fluids.

Solids that have sedimented against the bowl wall are removed manually from this type of centrifuge when the quantity is collected is sufficient to impair the quality of the clarification or separation.

Self-powered centrifugal fluid cleaning devices are well known for cleaning lubricating fluids of solid contaminants in engines and like mechanisms.

It will be appreciated that notwithstanding the simplicity and efficiency with which such devices separate solids from the fluid passing therethrough, there are a number of limitations attached to their usage which have hitherto served to limit their widespread use.

A typical form of such a self-powered centrifugal cleaner is shown in part sectional elevation at 10 in FIG. 1, comprising a base 11, rotor 12 mounted on a substantially vertical axis 13 for rotation thereabout, a housing 14 mounted on the base and enclosing the rotor and a drain or holding sump 15 formed in the base below the rotor. A fluid inlet passage 16 is arranged to supply fluid at elevated pressure to the interior of the rotor by way of the rotation axis and a fluid drain passage 17 in the base receives fluid from the drain sump for return to a fluid reservoir. The rotor has side walls arranged to retain solid contaminants, contained in the supplied fluid, which are forced outwardly by rapid rotation of the rotor due to reaction to ejection of the supplied fluid to the drain sump by way of rotor nozzles 18, 19 in the base thereof.

When used in a lubrication system for an engine or a fluid operated device, the quantity of fluid which can be passed through it in a given time is limited and the fluid emerging from the rotor nozzles 18 and 19 is in a low

energy state and suited only for returning by gravity flow to a system reservoir or sump.

It has been proposed to avoid draining limitations by exposing the housing to an above-ambient pressure, possibly from an engine crank case, although this then requires either a corresponding increase in supply pressure to maintain the pressure drop across the rotor nozzles or acceptance of a reduced rotation efficiency, or by using a suction pump driven by way of a power take off from the engine or machine being lubricated by the circulated fluid.

Another method proposed in the past to overcome the draining limitations of such centrifugal cleaners was to provide a cleaner in which a proportion of a circulated fluid is diverted with a drainage assistance arrangement including a venturi arrangement through which the non-diverted fluid is passed. The venturi could then develop a significant pressure drop in a region into which opens an induction port connected to the cleaner sump so that the cleaned fluid can be entrained into the non-diverted fluid and returned to circulation.

These methods have their problems particularly that the systems have not been effective in removal of the fluid from the base of the rotor. A failure to accomplish this effectively leads to the fluid "backing up" or accumulating in the base and this affects the rotor speed and therefore separation efficiency.

The present inventors have found a surprisingly efficient way of reducing the draining limitations of such apparatus.

Fluid dehydration units are also known. Devices and systems that have been used to remove water contamination include settling tanks or reservoirs, centrifuges, water absorbing filters, and vacuum dehydration oil purifiers. However, these have had significant limitations in either their water removal capabilities, ease of operation, capital costs, or operating costs, as will be discussed.

Settling tanks remove bulk quantities of "free" water from oil based on the difference in their densities and gravitational settling. To be effective in removing "free" water, settling tanks require large residence times and a significant amount of floor space. However, they are ineffective in separating

oil-water emulsions and are not capable of removing dissolved water.

Centrifuges accelerate the gravitational settling of water from oil by imposing centrifugal force on the fluid that, in effect, elevates the gravitational force.

Centrifuges are effective in removing free water from the oil. However, these centrifuges are generally expensive, and have limited capability of separating oil-water emulsions. They cannot remove dissolved water from the oil.

Water absorbing filters use special filter media that absorbs water from the oil. As the water is absorbed, the media swells, the flow is restricted, and the pressure drop across the filter rises. When the pressure drop reaches a predetermined level, the water absorbing filter is removed, disposed of, and a new filter is installed. These water absorbing filters are effective in removing free water but have marginal effect in removing emulsified or dissolved water from the oil. In addition, water-absorbing filters have a limited capacity for water. Therefore, they must be replaced once they are saturated with water. Consequently, they are typically only used in applications where trace amounts of water are present. In applications where water concentrations are higher, the cost of continuously replacing water-absorbing filters becomes very high.

Several types of vacuum dehydration oil purifiers have been used for oil dehydration. These generally operate under the principle of vacuum distillation, mass transfer of moisture from the oil to dry air, or a combination of the two.

In vacuum distillation, a vacuum is applied to reduce the boiling point of the water. For example, while the boiling point of water is 100° C) at 1013 mm H20 barometric pressure (standard atmospheric pressure), its boiling point at 100 mm H2O is only 50° C. By applying a sufficient vacuum relative to the temperature of the oil, the water in the oil will evaporate from the oil into the low-pressure air (vacuum), thus dehydrating the oil.

Flowing the oil into a contactor vessel which has a vacuum applied to it by means of a vacuum pump is the typical means by which this is achieved. In order to maximize the water vaporization rate in a given vessel, large

surface area-to-volume ratios of oil are preferred.

. This can be accomplished by means of flowing the oil over structured packing, random packing, cascading plates, spinning discs, or other methods well known in the vacuum distillation and contactor fields. The oil usually enters at the top of the contactor and flows gravitationally downward over the packing, spreading into relatively thin films. The oil collects in the bottom of the vessel where it must be pumped out by means of an oil pump. Heat may be added to the oil in order to reduce the amount of vacuum needed.

Vacuum is applied to lower the water boiling point, and to increase the water removal rate. Heat may also be applied to increase the water removal rate. However, great care must be taken in not applying too much heat and/or vacuum because more and more of the lower molecular weight hydrocarbons in the oil will also be vaporized as the temperature and/or vacuum is increased to levels below their boiling points. It should be understood that any liquid with a boiling point less than water will also be removed. This may, or may not be desirable, depending upon the application.

Mass transfer-based systems use similar contactor vessels. However, rather than relying on distillation for removal of the water, dry air or gas is continuously passed countercurrently upwards across the oil that flows downward. Water molecules in the oil will move via a concentration gradient into the relatively drier air. The now humid air is drawn from the contactor by a vacuum pump or blower and exhausted to atmosphere. It is not necessary to heat the oil more than the boiling point of water in order for the water to vaporize. Therefore, less heat and/or vacuum can be used for water removal with a mass transfer-based system than in vacuum distillation systems.

While vacuum distillation and mass transfer systems do remove free, emulsified and dissolved water, they have several drawbacks that have prevented their widespread use.

In both systems, liquid level controls are used within the vessel in order to ensure that the oil level does not become so low so that the oil pump runs dry. The liquid level controls also function to ensure that the oil level does not become so high that the vacuum vessel fills with oil. This would reduce or eliminate the water removal efficiency of the vessel and may even lead to the

oil entirely filling the vessel and overflowing into the vacuum pump.

Vacuum purifiers are also subject to foaming within the vessels as water is vaporized within the oil. This foam has a lower specific gravity than the oil can cause malfunctioning of the liquid level controls and a reduction in the performance of the purifier.

Due to their ability to remove free, emulsified or dissolved water from oil, vacuum dehydration oil purifiers have become the desired method for water removal from oil.

However, the drawbacks associated with vacuum oil purifiers have prohibited these purifiers from being widely used and/or are not practical on the majority of lubrication or hydraulic systems. Because of their relatively large size and costs, they are limited to non-mobile, stationary applications, and are not practical for use on mobile equipment.

Due to their high capital cost, they are typically not permanently installed in a system unless it is a relatively large, expensive lubrication or hydraulic system. Instead, they are usually shared by several systems by using one to purify the oil on one machine or reservoir for a period of time, and then move it to another machine, etc. However, when the purifier is being used in this manner, the oil in the machines that are not connected to the purifier can become contaminated with water. This oil will remain contaminated until the purifier can be reattached to them and the oil dehydrated again.

Membrane based systems have been used to remove water from organic systems. It must, however, be recognized that the presence of either pores or defects in a membrane used for this purpose will result in the hydraulic permeation of the oil to the permeate side. This situation will result in the loss of oil. It will also allow the non-volatile oil to coat the permeate side of the membrane, thereby fouling the membrane and reducing its effectiveness in permeating water.

The present inventors have also found a surprisingly simple yet efficient way of removing water from another fluid of low volatility.

SUMMARY OF THE INVENTION

The present invention is directed to an apparatus and method for fluid

cleaning, which may at least partially overcome the abovementioned disadvantages or provide the consumer with a useful or commercial choice.

In one broad form, the invention resides in a centrifugal cleaner for cleaning a fluid comprising:

a base,

a rotor mounted on a substantially vertical axis for revolution thereabout,

at least one rotor nozzle in a lower portion of the rotor,

a housing mounted on the base and enclosing the rotor and

an impeller positioned below the rotor adjacent the base to exert pressure on the fluid.

The apparatus and method of the present invention disclosed are particularly suited to the cleaning of oils and as such, explanation of the principles and processes are given referring to oils as the fluid to be cleaned. It will be appreciated by a person skilled in the art that other fluids may be cleaned using the present invention.

The oil cleaning centrifuge may include three sections - the centrifuge bowl or rotor, the driving nozzles and the oil level control mechanism or impeller, all contained in a suitable housing preferably manufactured of steel and cast aluminium.

To get to the centrifuge, dirty oil may enter the unit through the side of the centrifuge base and suitably travels up through a hollow spindle. The spindle may preferably be positioned at the axis about which the centrifuge bowl or rotor revolves.

At the top of the spindle, a baffle may distribute the oil uniformly into the centrifuge bowl or rotor. The bowl spins at high speed, preferably about 7500 rpm, and the oil quickly accelerates to a high speed. The resulting centrifugal force causes dirt to move outward onto the inside bowl wall where it mats into a dense cake.

The impeller may suitably be an open type impeller or a shrouded impeller. Closed type or shrouded impellers are generally the most efficient. Open or semi-open types are used for viscous liquids or for liquids containing solid materials and on many smaller pieces of equipment. The impeller may perform as a turbine pump.

The impeller may preferably comprise a central hub rotating on the central axis around which the rotor is revolving. The hub may preferably have at least one blade extending therefrom. The blades may be straight, curved in either the forward or backward direction depending upon the position of the impeller (that is whether the impeller is located to push the fluid or to suck the fluid).

The blades or vanes on the impeller may be angled or pitched. The pitch may be variable. The blades may partially overlap and define a plurality of passages between the blades.

The pressure exerted on the fluid may be due to centrifugal forces as in a centrifugal pump or of a positive displacement force as in a positive displacement pump.

The impeller may be provided with a loose inner sleeve to prevent tip leakage. The inner sleeve may be free to rotate under the frictional drag of the vanes and the viscosity of the liquid.

The impeller may preferably move the oil away from the base at a rate which is quicker than the flow from the nozzles. This may prevent or reduce the buildup of oil in the base which could cause the rotor to slow or lose efficiency.

The impeller may be attached to the rotor and if so the impeller may spin with the rotor. In this case the impeller may act as similarly to a pump impeller. The impeller may preferably be permanently fixed, screwed or cast to the base of the rotor. The inertia of the much larger and heavier rotor may preferably rotate the attached impeller. This impeller rotation together with the shape and configuration of the impeller blades preferably causes a sweeping action of the oil as it is ejected from the nozzles. The sweeping action may cause any oil contacting the blades to be directed into the drain sump away from the rotor. The impeller may suitably be smaller than the rotor so as not to unduly slow the rotor.

In another preferred aspect the impeller may be independent of the rotor. It may suitably be mounted on the same axis of rotation as the rotor and have blades shaped to utilize the force of the oil as it is ejected from the nozzles in order to impart rotational force on the impeller.

There may also be fins or vanes disposed in the base of the centrifugal cleaner to direct the oil away from the rotor. These vanes may guide the spent oil away from the rotor.

In another form, the invention resides in a centrifugal cleaner for cleaning a fluid comprising

a base,

a rotor having an interior and an exterior mounted on a substantially vertical axis for revolution thereabout,

at least one rotor nozzle in a lower portion of the rotor,

the rotor having side walls arranged to retain solid contaminants contained in the fluid which are forced outwardly by rapid rotation of the rotor due to reaction to ejection of the fluid to a drain sump through the rotor nozzles,

a housing mounted on the base and enclosing the rotor,

a drain sump formed in the base below the rotor,

a fluid inlet passage arranged to supply fluid at an elevated pressure to the interior of the rotor by way of the rotation axis,

at least one fluid drain passage in the base to receive fluid from the drain sump and

an impeller positioned below the rotor adjacent the base to exert pressure on the fluid.

In yet another form, the invention resides in a fluid cleaning system including at least one centrifugal cleaner. The centrifugal cleaner may be of any type.

In still another form, the invention resides in a vacuum dehydration unit for removing water from a fluid stream comprising

a vacuum chamber having a base,

a nozzle in an upper portion of the vacuum chamber for fluid entry,

means for generating a vacuum in the vacuum chamber,

a fluid discharge passage in a lower portion of the vacuum chamber extending a distance above the base of the housing to maintain a depth of fluid in the base of the vacuum chamber, and

an internal baffle extending into the fluid maintained at the base of the vacuum chamber, thereby defining two areas within the vacuum chamber.

The system operates according to the principle that water boils at a lower temperature as pressure is reduced. The lower the pressure, the lower the boiling temperature. It is therefore possible to boil water contaminating oil or other substance with low relative volatility at temperature closer to ambient. The boiling will preferably cause the formation of steam or water vapour which may then be condensed on a coalescer inside the vacuum chamber and removed by the device creating the vacuum. The oil may be removed from the vacuum chamber by a combination of gravity flow, which may defy the vacuum and a pump associated with the fluid discharge passage.

The result may be that any aqueous solution such as water and acids may be removed via the vacuum generating device and collected in a waste chamber for disposal or reuse. Water levels to les than 10 ppm may preferably be achieved in the oil. The oil may then be further cleaned in the centrifugal cleaner.

The nozzle for fluid entry may receive oil pumped from a reservoir under pressure. The flow of the oil under pressure may cause the oil to be atomised upon entry into the low pressure environment inside the vacuum chamber.

The vacuum generating device used in conjunction with the present invention may suitably be a small readily available air operated venturi vacuum jet unit.

The vacuum dehydration chamber may preferably have at least one tray or other means to increase the surface area of oil exposed to the vacuum. The trays may take the form of condenser trays to allow the oil vapour to condense back into liquid. The trays may suitably be angled to allow the condensed liquid to be directed towards the base of the vacuum chamber.

The trays may have an array of openings therein to allow the liquid to run through the openings.

The chamber may be of any shape suitable for use in a compact unit while still accomplishing its function. There may suitably be a means for measuring the extent of the vacuum formed in the vacuum chamber either inside or in association with the vacuum chamber.

There may be a second discharge outlet provided for the removal of water or water vapour from the vacuum chamber. There may be an accumulator associated with the second outlet.

The fluid discharge passage may be associated with a pump for moving the oil discharged from the vacuum chamber. A non-return valve may also be fitted to the discharge pipe to prevent backflow.

The internal baffle extending into the fluid maintained at the base of the vacuum chamber, defining two areas within the vacuum chamber may suitably be angled to allow the oil vapour on one side of it to condense on the angled surface and run down.

In still another form, the invention resides in a fluid cleaning system including at least one vacuum dehydration unit.

In yet another form, the invention resides in a fluid cleaning system including at least one centrifugal cleaner, and at least one vacuum dehydration unit.

The fluid cleaning systems may also include, at least one holding tank, at least one heating unit and at least one pump.

The fluid cleaning system may suitably be portable.

The holding tank may be used at the discretion of the operator of the system as may the heating unit and the pump(s). The individual units may be turned on and off at the discretion of the operator. The units may also be controlled to maintain pre-set optimum conditions within the system. The units may appear in the system in any order.

The heating unit may allow the system to be used to clean heavier grade oils. The purpose of the heater is to heat the oil, creating a reduction in the viscosity of the oil. The heater may preferably be mounted after the first pump discharge and allow the oil to pass through prior to entry to the centrifuge. The element may be a thermostatically controlled element and may also allow the operator to pre-set a temperature for optimum operation.

There may preferably be two pumps in the system each driven from an end of a double ended motor. Alternatively, both pumps may be driven from the one end of the motor which may allow an element of submergibility in some situations. The first pump may preferably move oil from the holding

tank to the heater and from there to the centrifuge. The second pump suitably carries oil away from the centrifuge at pre-set pressures allowing the system to be used as an in-line filtration system. Each pump may preferably be a gyrotary pump. Pumps of this type generally have a small central gear rotating inside a larger annular gear causing the larger annular gear to rotate. These pumps also generally have larger than normal porting, enabling them to transport high viscosity fluids. They preferably have a higher tolerance to wear from particle contamination than another type of hydraulic pump.

A preferred order of processes may be moving the oil from the holding tank through the heating unit, using a pump, then through the vacuum dehydration unit to remove the majority of the water. The oil may then proceed through the centrifugal cleaner and then back to the holding tank. In this system layout, provided the volume of oil to be cleaned is smaller than the holding tank volume, the entire volume of oil may be removed from the machine it lubricates into the device of the present invention for cleaning.

The system may preferably operate in a circulation pattern similar in nature to the cleaning of blood by the kidneys. The oil may preferably be continuously circulated through the oil cleaning system and returned to its origin as an ongoing process. The oil may be continuously circulated through the oil cleaning system diluting the contamination on each pass until a suitable level of cleanliness is achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the invention will be described with reference to the following drawings, in which:

Figure 1 is a part sectional elevation of a prior art self-powered centrifugal cleaner.

Figure 2 is a part sectional view of a centrifugal cleaner according to an aspect of the present invention.

Figure 3 is a perspective view of a disassembled centrifuge.

Figure 4 is a perspective view of a centrifuge rotor.

Figure 5 is a perspective view of a centrifuge with the housing removed.

Figure 6 is a close up view of the base of the centrifuge rotor.

Figure 7 is a perspective plan view of the base of the centrifuge.

Figure 8 is an end view of the fluid cleaning system according to an aspect of the invention.

Figure 9 is a reverse end view of the fluid cleaning system according to an aspect of the invention.

Figure 10 is a close up view of a portion of the fluid cleaning system according to an aspect of the invention.

Figure 11 is a close up view of another portion of the fluid cleaning system according to an aspect of the invention.

Figure 12 is a close up view of yet another portion of the fluid cleaning system according to an aspect of the invention.

Figure 13 is a close up view of still another portion of the fluid cleaning system according to an aspect of the invention.

Figure 14 is a schematic of the vacuum dehydration unit according to an aspect of the invention.

Figure 15 is a schematic of the oil cleaning system according to an aspect of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

According to a first aspect, the invention resides in a centrifugal cleaner 20 for cleaning a fluid comprising a base 11, a rotor 12 having an interior and an exterior mounted on a substantially vertical axis 13 for revolution thereabout, two rotor nozzles 18, 19 in a lower portion of the rotor 12, the rotor 12 having side walls arranged to retain solid contaminants contained in the fluid which are forced outwardly by rapid rotation of the rotor 12, the rotation due to reaction to ejection of the fluid to a drain sump 15 through the rotor nozzles 18, 19, a housing 14 mounted on the base 11 and enclosing the rotor 12, the drain sump 15 formed in the base 11 below the rotor 12, a fluid inlet passage 16 arranged to supply fluid at an elevated pressure to the interior of the rotor 12 by way of the rotation axis 13, at least one fluid drain passage 17 in the base 11 to receive fluid from the drain sump 15 and an impeller 21 positioned below the rotor 12 adjacent the base 11 to exert pressure on the fluid.

As seen in Figure 2, the housing 14 is essentially bell-shaped with a

fixture 22 at the top of the housing to allow the spindle 23 disposed along the central vertical axis 13 to be inserted therein. The housing 14 is manufactured from a strong but relatively lightweight material such as stainless steel and it will generally be polished on the inner surface to reduce the friction between it and the fluid to be cleaned. The housing 14 is located relative to the base 11 by positioning an opening 24 disposed in an upper portion of the housing 14 over the protruding spindle 23 and securing the housing 14 in that position. The interior of the housing 14 may also have circular spacer members for maintaining the position of the rotor 12 within the housing 14 even when the rotor 12 is revolving at a high rate.

The spindle 23 is also generally the entry point for oil at 100psi into the centrifuge rotor 12. The oil enters the spindle through a fluid inlet passage 16.

The spindle 23 is a hollow elongate cylindrical member. It is manufactured from polished metal to reduce friction and wear to both itself and the centrifuge rotor 12. The spindle 23 is fixed to the base so that the housing 14 and the rotor 12 may be lifted from the spindle 23 for disassembly. An upper portion 25 of the spindle 23 is clamped with a nut 26 or other device to secure the housing 14 in position.

The base 11 is generally bowl shaped to allow the collection of the cleaned fluid and the direction of this fluid towards the outlet 17. The base 11 includes a number of directing fins 27 to contribute further to the direction of the fluid to the outlet or fluid drain passage 17. The base 11 is manufactured in a single piece and may be cast. The base 11, as with the other centrifuge components, is manufactured from polished metal to reduce friction between itself and the fluid to be cleaned. There are two opposed fluid drain passages 17 in the base 11 located on opposite sides of the spindle 23.

The housing 14 and the base 11 fit together with a substantially fluid tight seal to prevent or minimise leaks. A gasket 29 is used to enhance the seal. A collar 28 may also be used to further improve the sealing characteristics. The collar 28 is a circular collar which fits over enlarged portions on the housing 14 and the base 11 to form the seal.

The rotor 12 seen best in Figure 5, is manufactured of stainless steel.

It is generally tubular and cylindrical in design and has a laterally extending portion 30 towards the base of the rotor 12 to correctly position it within the housing, even when revolving at high speed.

The base of the rotor 12 and the upper portion of the rotor 12 have openings 24 therein to engage with the spindle 23 extending from the base 11. The openings 24 are fitted with bearings 31 to reduce the friction between the rotor 12 and the spindle 23. The openings 24 are situated in the centre of the upper and lower portions of the rotor 12.

There are two nozzles 18, 19 diametrically opposed on the base of the rotor 12. The nozzles 18, 19 are oriented substantially parallel with the spindle 23 in order to provide the optimum amount of rotational force to the rotor 12. Each nozzle 18, 19 is associated with a cowling 32 which is streamlined to provide lowered resistance in relation to the fluid when the rotor 12 in spinning.

According to a second aspect of the present invention, a vacuum dehydration unit 35 for removing water from a fluid stream is provided. The vacuum dehydration unit 35 comprises a vacuum chamber 36 having a base 37, a nozzle 38 in an upper portion of the vacuum chamber 36 for fluid entry, a vacuum generating device 39 associated with an outlet 43 from the vacuum chamber 36, a fluid discharge passage 40 in a lower portion of the vacuum chamber 36 extending a distance 41 above the base 37 of the vacuum chamber 36 to maintain a depth of fluid in the base 37 of the vacuum chamber 36, and an internal baffle 42 extending into the fluid maintained at the base 37 of the vacuum chamber, thereby defining two areas within the vacuum chamber 36.

The vacuum chamber 36 is substantially sealed to prevent the ingress of any atmosphere which would give rise to an increase in pressure. The inlets 49 and outlets 40, 43, to and from the vacuum chamber 36 will also be substantially sealed to maintain the low pressure environment.

The vacuum or lowered pressure environment is maintained in the chamber through the action of a vacuum generating device 39. The device 39 used in conjunction with the present invention is a small, readily available air operated venturi vacuum jet unit. The vacuum generating device 39

operates through an outlet 43 to remove atmosphere and also condensed water from the vacuum chamber 36. The vacuum generating device 39 is associated with a waste collection chamber 44.

The oil or other fluid enters the vacuum chamber 36 through the nozzle 38 in an upper portion of the vacuum chamber 36. The nozzle 38 is designed to atomise the oil or other fluid upon introduction to the low pressure environment.

The atomised fluid increases the surface area of the water in the oil which boils at a lowered temperature due to the lower pressure in the vacuum chamber 36. The more volatile oil generally does not boil. The water vapour makes its way towards the upper regions of the vacuum chamber 36 and the oil towards the base 37 of the vacuum chamber 36.

The oil makes its way to the base 37 of the chamber 36 via a system of condenser trays 45 provided in the vacuum chamber 36. The trays 45 are oriented at an angle to promote the flow of the oil towards the base 37. The trays 45 may form a waterfall type system.

At the base 37 of the vacuum chamber 36, there is a fluid discharge passage 40 extending a distance 41 above the base 37 of the vacuum chamber 36 to maintain a depth of fluid in the base 37 of the vacuum chamber 36. This depth of liquid promotes the condensation of the oil which has been atomised at the inlet nozzle 38.

The vacuum chamber 36 is provided with an internal baffle 42 extending into the fluid maintained at the base 37 of the vacuum chamber 36, thereby defining two areas within the vacuum chamber 36. The baffle 42 separates the vacuum chamber 36 into a liquid discharge area 46 and a condensing area 47. Due to the baffle 42 extending into the liquid maintained at the base 37 of the chamber 36, any oil which remains as atomised oil cannot pass into the liquid discharge area 46 of the chamber. The baffle 42 will therefore be substantially impermeable to the atomised oil.

There is a water condenser tray 48 in the uppermost portion of the chamber 36 to allow the water vapour to condense on. This tray 48 is also angled to guide the liquid water to the vacuum generating device 39 and its associated outlet 43 for removal.

As can be seen in Figure 15, an aspect of the invention also provides an oil cleaning system 50. The components in the oil cleaning system may be used in any order and any combination.

As can be seen in the schematic Figure 15, the oil enters the oil cleaning system 50 through an inlet pipe 51. Positioned on this inlet pipe 51 is a three way selector valve 52 allowing the operator to select whether the oil to be cleaned is taken from the holding tank 53 or an external source.

If the selector is positioned to take the oil from the holding tank 53, the oil will be collected from a suction sump 54 located in a lower portion of the holding tank 53 and transported to the entry to the system through piping 55.

At the entry to the system will be a suction strainer 56. This strainer 56 will remove larger particles and contaminants down to the 125 µm size.

The oil will then continue to a first pump 57. This pump 57 is powered by a motor 58 which may power more than one pump. The pump 57 moves the oil to the in-line heater 59. The heater 59 possesses a thermostat and switching device to control a preset heat or temperature in the heater 59. The heater 59 may be switched off so that no heat is provided to the fluid stream. The fluid will however usually pass through the heater 59 regardless of its state of activation.

The oil exiting the heater 59 may enter the centrifuge 60 directly or may be diverted to enter the vacuum dehydration unit 35. The stream may be split with a portion entering both. The oil exiting the vacuum dehydration unit 35 will then enter the centrifuge 60 or be returned to the holding tank 53.

There is also a second pump 61 driven by the motor 58 driving the first pump 57. This pump 58 takes oil from the suction sump 54 at the lower portion of the holding tank 53 and expels it from the system 50. It can also transport the oil exiting the vacuum dehydration unit 35 to the holding tank 53.

The system 50 functions so that any of the three main processes (vacuum dehydration unit 35, oil centrifuge 60 and Heater 59) can be operated at the discretion of the operator. The processes may be activated of deactivated at any stage. The system 50 may allow the oil to proceed through all three processes or any combination thereof. The pumps 57, 61 are provided to allow the transport of the oil into the system, out of the system

and around the system. A plurality of valves 52 is also provided to allow the system 50 to operate as an in-line system or a recirculating system treating oil stored in the holding tank 53.

The oil leaving the system 50 leaves via a final filter 62.

The oil cleaning system in an embodiment is shown in Figures 8 to 13. The portable oil cleaning system is shown having a chassis on wheels. The chassis supports the holding tank 53 and the other system components as described above, are located adjacent the holding tank 53.

In the present specification and claims, the word "comprising" and its derivatives including "comprises" and "comprise" include each of the stated integers but does not exclude the inclusion of one or more further integers.

In compliance with the statute, the invention has been described in language more or less specific to structural or methodical features. It is to be understood that the invention is not limited to specific features shown or described since the means herein described comprises preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted by those skilled in the art.

Dated this 29th day of October 2002

Robert C SMITH and **Robyn C SMITH**

By their Patent Attorneys

CULLEN & CO.

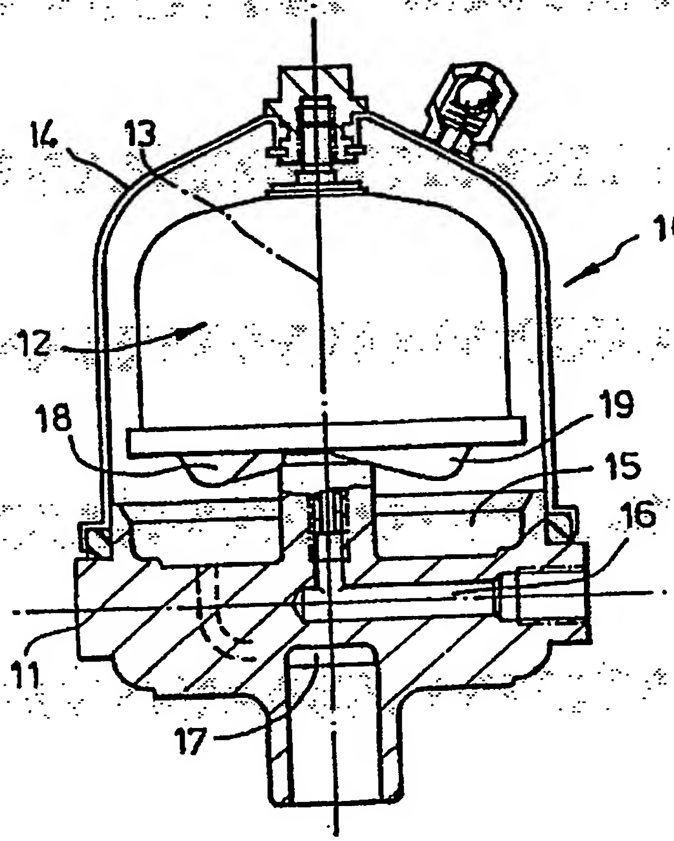


FIG.1
(PRIOR ART)

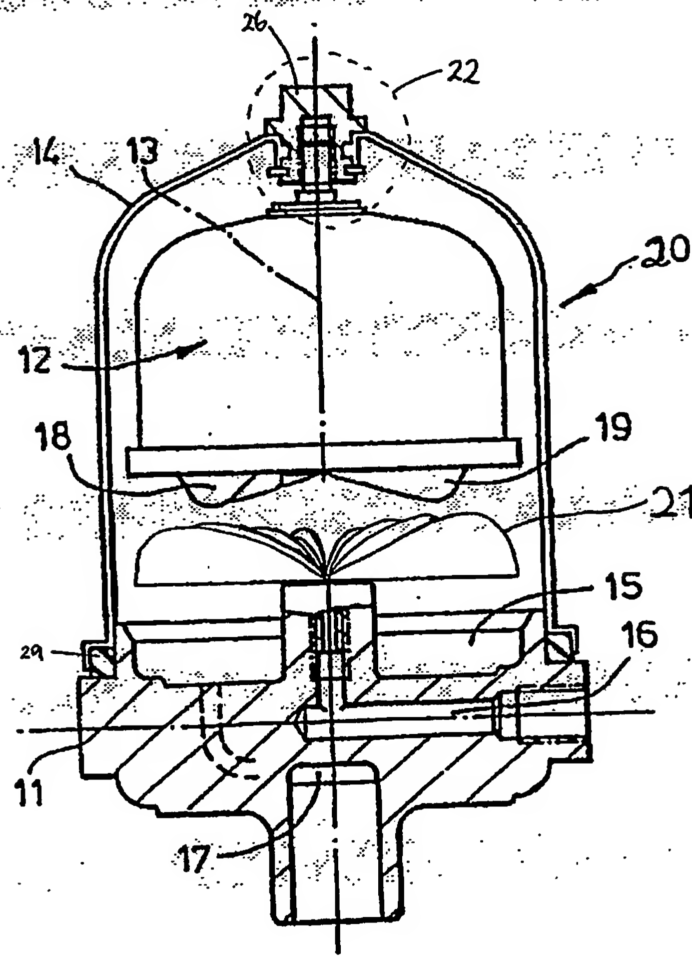


FIG. 2

FIGURE 3

FIGURE 4

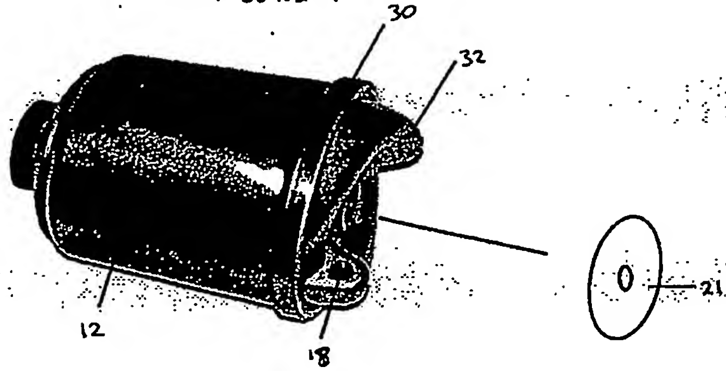


FIGURE 5

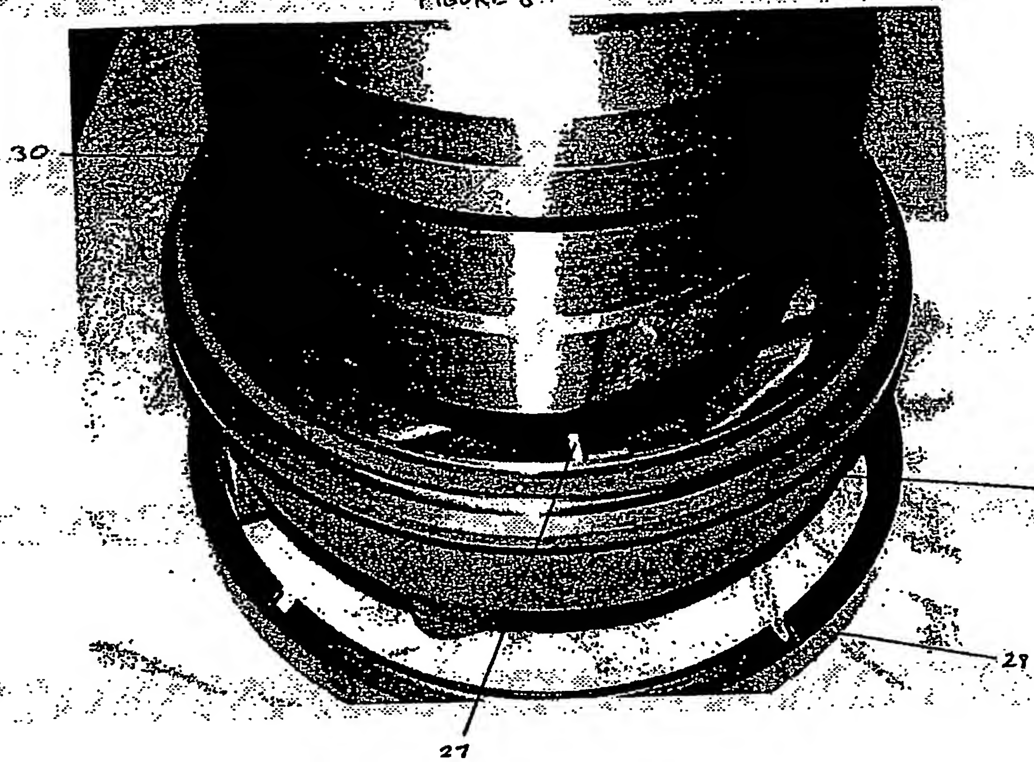


FIGURE 6

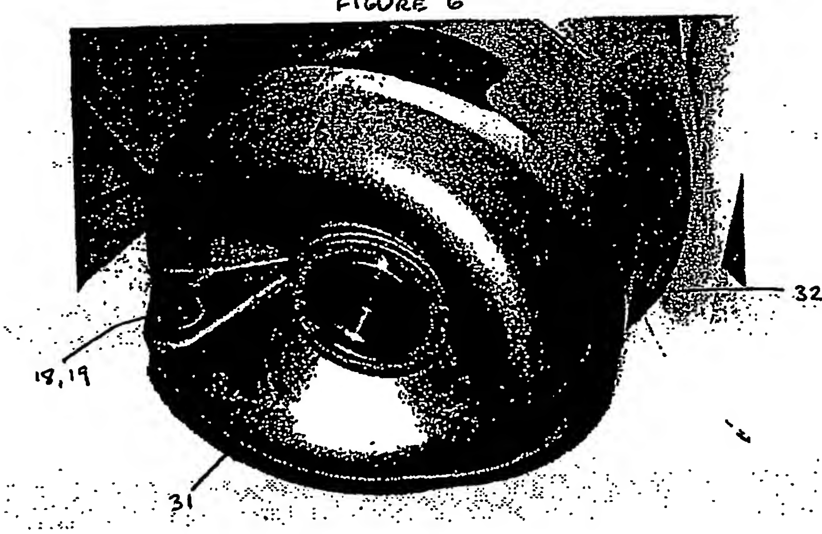


FIGURE 7

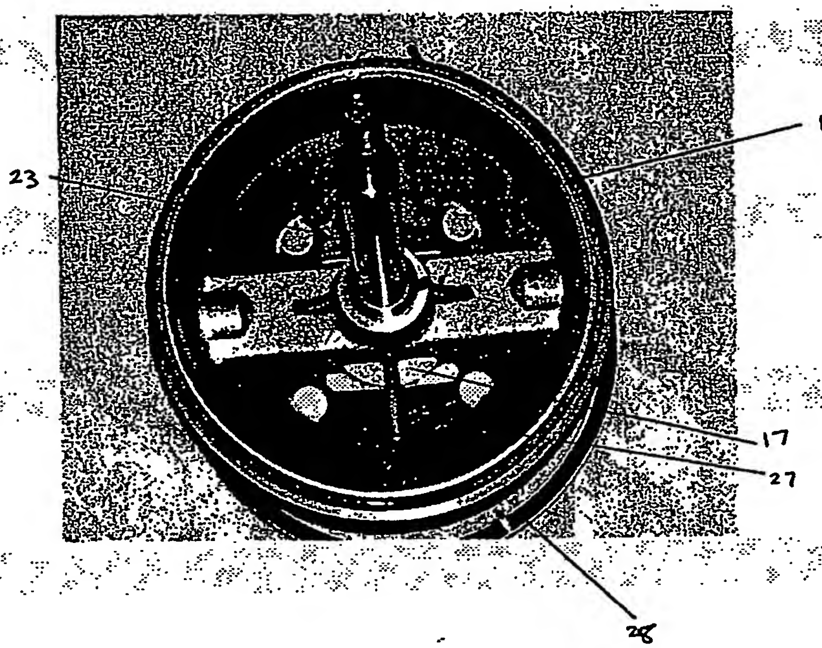


FIGURE 8

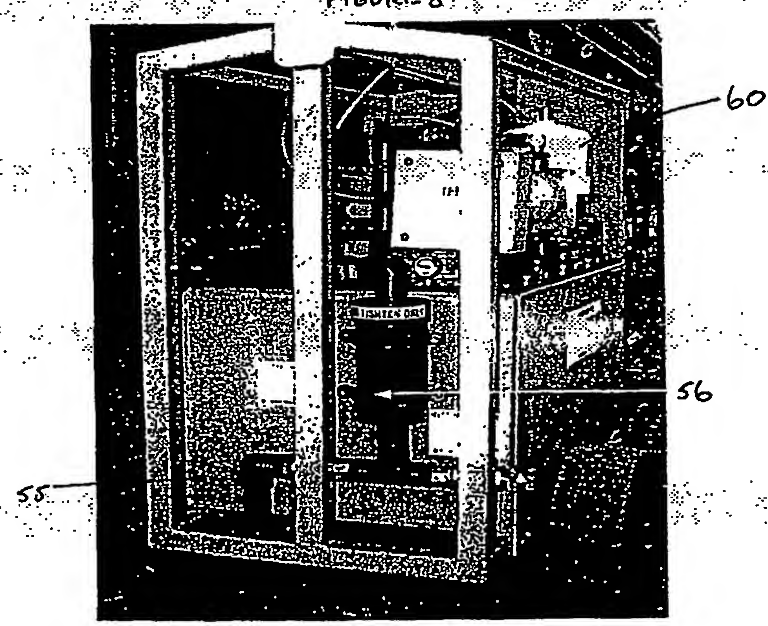


FIGURE 9

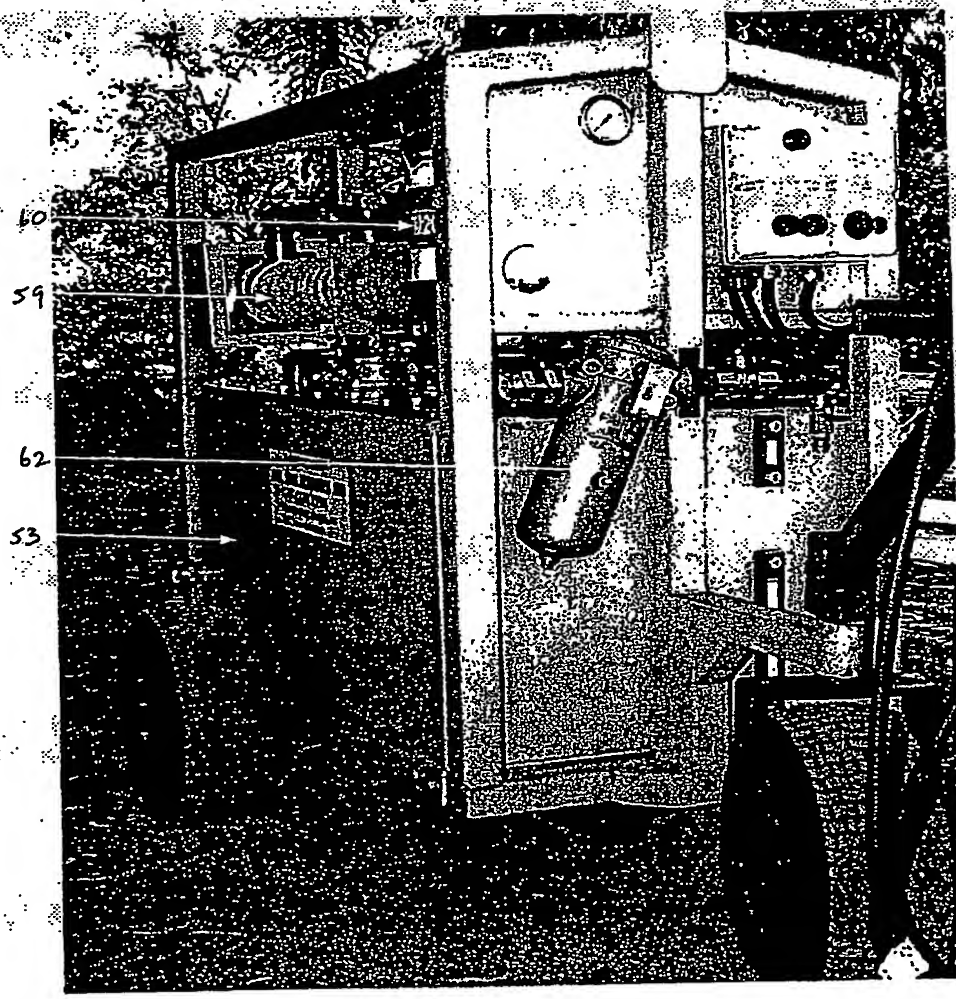


FIGURE 10

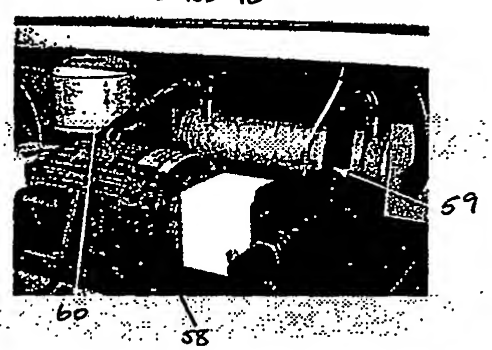


FIGURE 11

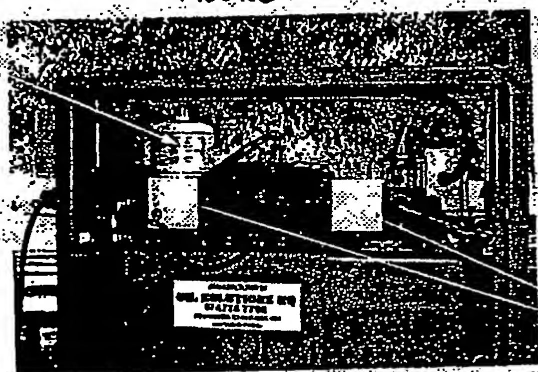


FIGURE 12

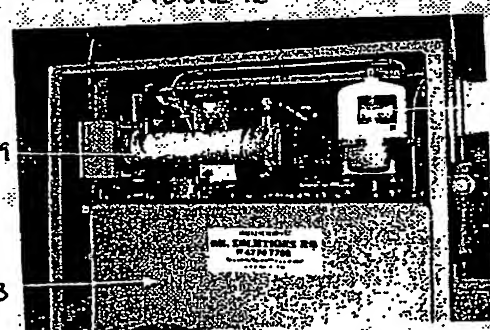
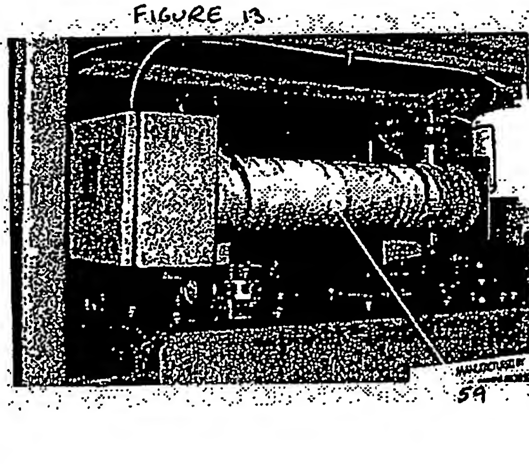


FIGURE 13



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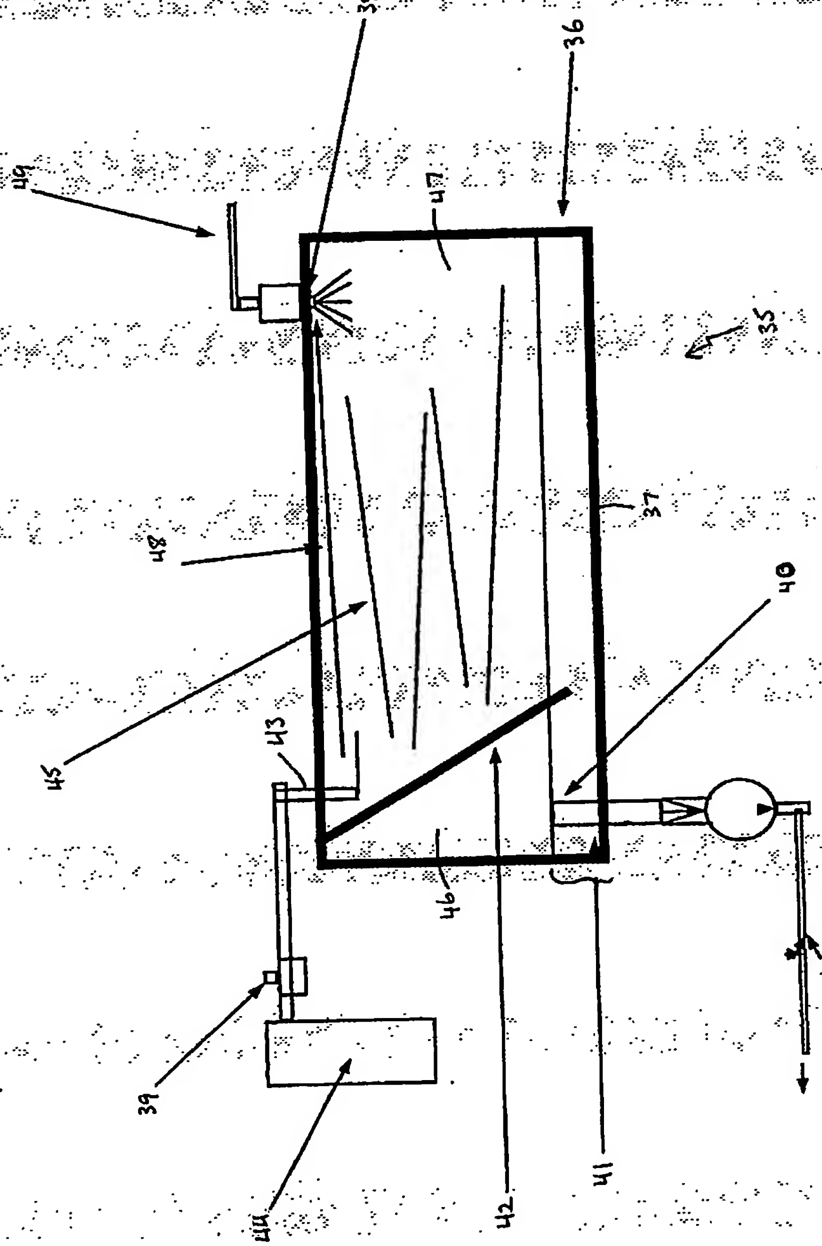
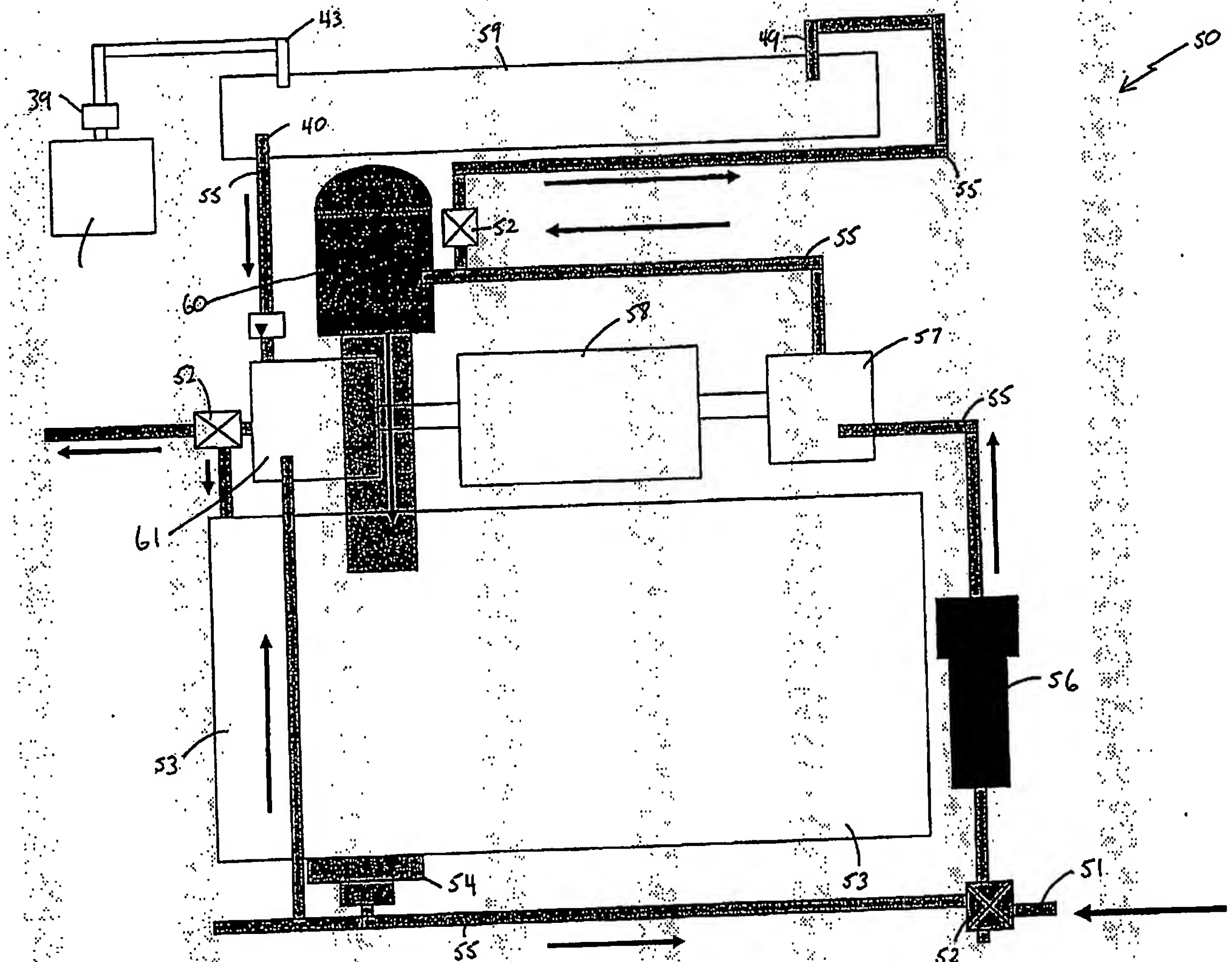


FIGURE 14

FIGURE 15



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